Table 1: The diet and its preference by the Nicobar Megapode

Food item	Rank based on Volumetric proportion	Rank based on frequency of occurrence
Macaranga peltata	1	1
Dictyoptera (cockroaches)	2	2
Snails	2	3
Litters	3	2
Beetles	4	4
Ants	4	4
Unidentified	4	3
Grasshopper	4	5
Pauropodans	5	5
Hermit crab	5	5
Reptile scale	6	6

Like other megapodes, the Nicobar Megapode also forages by scratching and raking the debris on the ground. More precipitation reduced the foraging activities of the Nicobar Megapode (Spearman correlation test: r_s= -0.46, p= 0.05). Foraging patterns varied significantly between the years (Kruskal Wallis test: H= 9.23, df= 2, p<0.01), due to significant variation in precipitation (Kruskal Wallis test, H= 7.81, df= 2, p= 0.02). The data reported here agreed with other reports for the genus *Megapodius*: that they are omnivorous (Jones *et al.* 1995).

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K. SIVAKUMAR[1]
R. SANKARAN
Sálim Ali Centre for Ornithology
and Natural History,
Anaikatty, Coimbatore 640108,
Tamil Nadu, India
[1]Present Address: Wildlife Institute of India,
P.O. Box. 18, Chandrabani,
Dehra Dun 248 001, Uttaranchal, India.
E-mail: ksivakumar@wii.gov.in

REFERENCES

Ali, S. & S.D. Ripley (1983): Handbook of the Birds of India and Pakistan. Compact edition. Oxford University Press, Bombay. 737 pp.

Altmann, J. (1974): Observational study of behaviour: sampling methods. *Behaviour 48*: 227-265.

Booth, D. T. (1986): Crop and gizzard contents of two Mallee fowl. *Emu 86*: 51-53.

Brookes, G.B. (1919): Report on investigations in regard to the spread of prickly pear by the Scrub Turkey. *Queensland Agricultural Journal 11*: 26-28.

Cleland, J.B. (1912): Examination of contents of stomachs and crops of Australian birds. *Emu 12*: 8-18.

Coles, C. (1937): Some observations on the habits of the Brush Turkey (*Alectura lathami*). *Proceedings of the Zoological Society of London 107(A)*: 261-73.

Gill, H.B. (1970): Birds of Innisfail and hinterland. *Emu 70*: 105-116.

Hess, H.C. (1997): Stomach flushing: sampling the diet of Red-cockaded Woodpecker. *Wilson. Bull. 109(3)*: 535-539.

Jones, D.N., R.W.R.J. Dekker & C.S. Roselaar (1995): The Megapodes. Oxford University Press. 262 pp.

Kennedy, M & P. Fitzmaurize (1972): Some aspects of the biology of gudgeon *Gobio gobio* (L.) in Irish waters. *J. Fish. Biol. 4*: 425-440.

11. GRIT USE IN THE SARUS CRANE *GRUS ANTIGONE*

Introduction

Grit is generally ingested by granivorous and herbivorous birds, and to a smaller extent by insectivorous birds (Weltry and Baptista 1988). The main purpose of grit intake by birds is to facilitate the mechanical grinding in the gizzard of any hard, coarse material ingested by the bird. However, grit may also provide calcium to female birds just before the breeding period (Harper 1964). Grit use patterns are fairly well understood for Galliformes (Dalke 1937; Sadler 1961) and for 'cornfield birds' (Best and Gionfriddo 1991; Gionfriddo and Best 1996). While several observations have been made towards ingestion of grit particles by Sarus Cranes (J. Langenberg *pers. comm.*, M. Nagendran *pers. comm.*, K.S.Gopi Sundar *pers. obs.*), no information exists on the amount and kind of grit ingested by Sarus Cranes. In this paper, we present information on grit use by the Sarus Crane in India based on contents of three Sarus Crane gizzards.

METHODS

The gizzards of three Sarus Cranes (one each of a sub-adult, male and female bird), which had been collected after their death due to suspected pesticide poisoning (S. Sharma, *pers. comm.*), were obtained from Keoladeo Ghana National Park in Bharatpur, India. The age of these birds were unknown

and could only be inferred from the development of the red colouration on the head (Ali and Ripley 1980). The gizzards were found to contain large amounts of vegetable matter and grit. The gizzards were sliced open, all the contents were flushed onto petri dishes, and the grit separated, washed and dried.

Characterization of grit was done following Best and Gionfriddo (1991). Three measurements used to characterize the grit were: 1) Size - the average of the longest and the shortest dimensions of each particle was calculated by measuring the two dimensions with Vernier callipers to the nearest 0.01 mm. 2) Shape - grit shape index was calculated by dividing the longest dimension with the shortest. The particles representing a spherical shape would have an index of 1.0 and grit with values greater than unity were deemed oval to oblong, and 3) Roundness - grit roundness was measured by classifying all particles in five categories, namely Angular, Sub-angular, Sub-rounded, Rounded and Well-rounded. Roundness index was calculated by giving grit particles a value of 1 for Angular, 2 for Sub-angular and so on; values tending towards five would mean grit with completely smooth surfaces.

Grit particles with the longest dimension <1 mm were excluded from the analysis, assuming that they were accidentally ingested by the cranes, or were broken down from larger particles. Very few particles (<1%) were excluded from the total sample for this reason. All grit particles of each bird were weighed together to the nearest 0.01 gm.

RESULTS

A total of 523 grit particles were counted and measured from the gizzards of the three Sarus Cranes. The total weight, number of grit particles, mean grit size and mean grit shape are indicated in Table 1. Though the male bird had the highest mean grit size, the two largest grit particles (> 10 mm) were found in the other two birds. The largest range of grit sizes was seen in the sub-adult and female bird (Fig. la). Most grit particles (80.7%) in all three gizzards were between 2-6 mm in size (Fig. 1b). While the sub-adult and the female bird had most grit particles in the size range of 2-4 mm, the male bird had most grit particles in the 4-6 mm range (Fig. la). Most of the particles (69%) had a shape index of 1.5-2.5 (Fig. 1b). The male bird had the largest variety of shapes (9 classes) and the female, the least (6 classes). All three birds used most of the grit particles in the shape index range of 1.5-2 (Fig. 1b). The most represented grit roundness categories were Sub-angular and Sub-rounded (77.6% of all particles, Fig. 1c). The least represented roundness category was Well-rounded (n=1) in the entire sample. The largest proportion of Angular particles

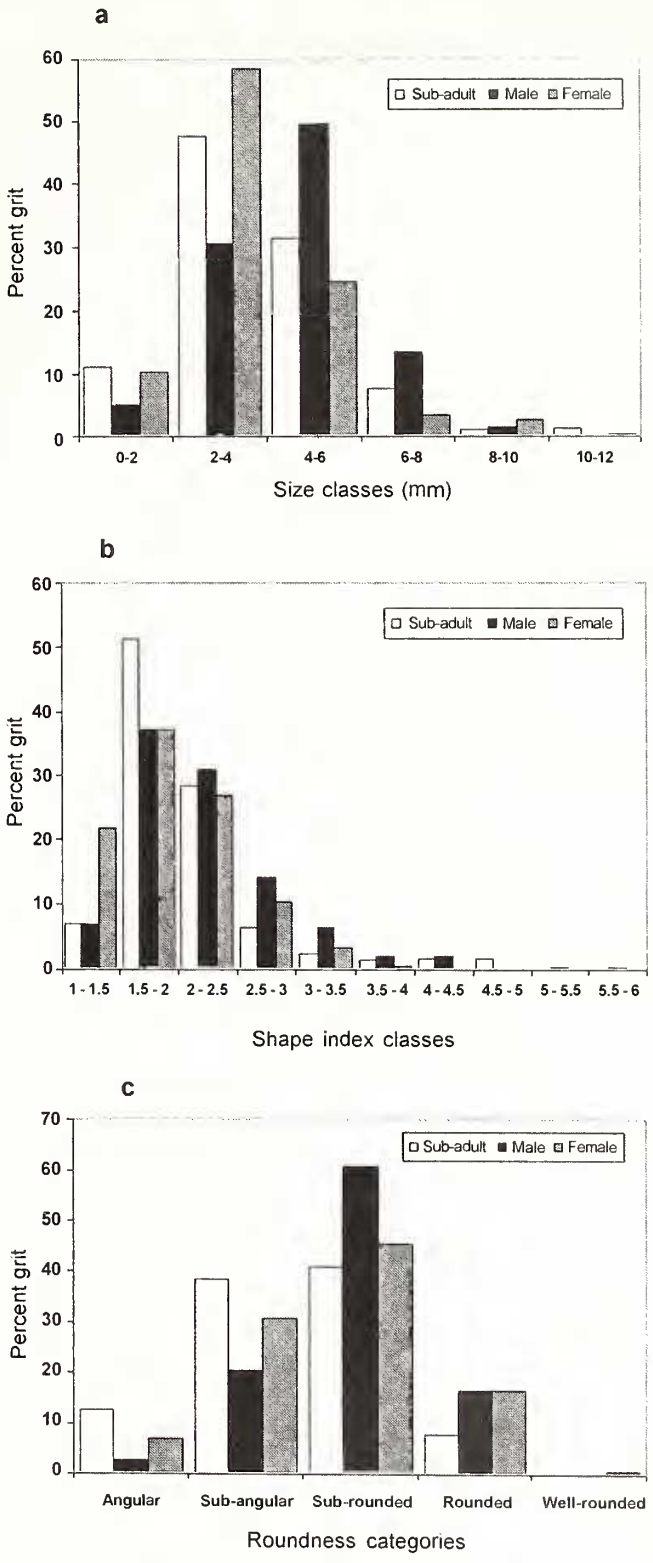

Fig. 1: a. Percent composition of grit particles across different size classes;
b. Percent composition of grit particles across different shape index classes;
c. Percent composition of grit particles across different roundness categories

Table 1: Characteristics of grit in Sarus Cranes

Gizzards sampled	Number of grit particles	Total weight (gm)	Mean size (mm)	Shape index	Mean Roundness
Sub-adult	108	13.46	3.92 (1.1-10.41)	2.01 (1.18-4.55)	2.45
Adult male	220	35.95	4.5 (1.28-8.57)	2.2 (1.11-5.62)	2.94
Adult female	195	22.65	3.68 (1.03-11.8)	1.94 (1.17-3.89)	2.74

Range of mean size and shape index of grit is given in parentheses

was seen in the sub-adult bird. All three birds used most of the grit particles in the Sub-rounded category (Fig. 1c). Mean roundness of grit particles was almost the same in all three birds (Table 1).

DISCUSSION

While use of grit in birds is known to differ with body size, gender, reproductive status and availability, diet is known to be the most important factor influencing use of grit (Gionfriddo and Best 1996). Increase in number of grit particles is usually in bird species with a diet of hard, coarse material, particularly seeds and vegetable matter (Gionfriddo and Best 1996), and in species with a varied, unspecialized diet. The Sarus Crane (*Grus antigone*) in India is known to be omnivorous, its diet including grain of several kind, plant shoots, tubers of aquatic plants, frogs, lizards and other reptiles, grasshoppers and other insects, vegetable matter, fruits, molluscs (Hume and Marshall 1879, Baker 1929, Ghorpade 1975), fish (Law 1930) and occasionally eggs of other birds (Sundar 2000). The omnivorous habit of the species most likely facilitates the intake of such large quantities of grit. Many of the foods reported for the Sarus are calcium-rich, and it is unlikely that grit is ingested to supplement calcium, but primarily fulfils a mechanical function.

Sarus Crane males are larger than females, and sub-adults are considerably smaller than adult birds (Ali and Ripley 1980). This may explain the difference in the higher number of grit particles and the corresponding weight of the gizzard of the male bird, and the smaller values for the other two birds (Table 1). Most of the grit particles used by the male bird were also of a higher size class compared to those in the other two birds (4-6 mm as against 2-4 mm). Larger sample sizes will be required to adequately explore gender and age related differences in grit use patterns in Sarus Cranes.

From this study, it appears that Sarus Cranes generally use grit particles between 2-6 mm in size and opt for grit particles with intermediate degrees of roughness and roundness. In theory, angular particles with sharp edges have the greatest efficiency in digesting coarse food substances, but also pose the risk of damaging internal digestive organs. In contrast, well-rounded particles have the lowest risk with respect to physical injury, but will be least efficient in breaking down food. In this respect, Sarus Cranes seem to be using grit particles to maximize digestion while avoiding excessive physical damage to digestive organs. This data set is useful in that it provides information to aviculturists and zoo managers on the kind of grit that should be provided to captive Sarus Cranes.

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K.S. GOPI SUNDAR[1]
B.C. CHOUDHURY
Wildlife Institute of India,
P.O. Box 18, Chandrabani,
Dehra Dun 248 001, Uttaranchal, India.

[1]Present Address: C/o Wildlife Society of India,
M-52, Greater Kailash Part-1,
New Delhi 110 048, India
Email: gopi@savingcranes.org

REFERENCES

Ali, S. & S.D. Ripley (1980): Handbook of the Birds of India and Pakistan. Vol 2: Megapodes to Crab Plover. Oxford University Press, Delhi.

Baker, E.C.S. (1929): The game birds of the Indian Empire Vol. V. The waders and other semi-sporting birds. Part VII. *J. Bombay Nat. Hist. Soc. 33*: 4.

Best, L.B. & J.P. Gionfriddo (1991): Characterization of grit use by cornfield birds. *Wilson Bull. 103*: 68-82.

DALKE, P.L. (1937): Food habits of adult pheasants in Michigan based on crop analysis method. *Ecology 18*: 199-213.

GHORPADE, A.M. (1975): Notes on the feeding of the Sarus Crane *Grus antigone antigone* (Linnaeus). *J. Bombay Nat. Hist. Soc. 72*: 199-200.

GIONFRIDDO, J.P. & L.B. BEST (1996): Grit-use patterns in North American birds: the influence of diet, body size, and gender. *Wilson Bull. 108*: 685-696.

HUME, A.O. & C.H.T. MARSHALL (1879): The Game Birds of India, Burma & Ceylon. Vol III. John Bale, London. Pp. 4-5.

HARPER, J.A. (1964): Calcium in grit consumed by hen pheasants in east-central Illinois. *J. Wildl. Manage. 28*: 264-270.

LAW, S.C. (1930): Fish eating habit of the Sarus Crane (*Antigone antigone*). *J. Bombay Nat. Hist. Soc. 34*: 582-583.

SADLER, K. (1961): Grit selectivity by the female pheasant during egg production. *J. Wildl. Manage. 25*: 339-341.

SUNDAR, K.S.G. (2000): Eggs in the diet of the Sarus Crane (*Grus antigone*). *J. Bombay Nat. Hist. Soc. 97*: 428-429.

WELTRY, J.C. & L. BAPTISTA (1988): The Life of Birds. Saunders College Publishers, N.Y.

12. OBSERVATIONS OF MATE CHANGE AND OTHER ASPECTS OF PAIR-BOND IN THE SARUS CRANE *GRUS ANTIGONE*

Sarus Cranes *Grus antigone* are known to be monogamous and pair bond is thought to last throughout the lives of the birds (Ali and Ripley 1989). The male and female of a pair are known to strengthen the pair bond by synchronized behaviours such as duet calls, dance, guard-calls and alarm-calls (Masatomi 1994; Archibald 1976). The actual duration of pair bond, prevalence of mate change and factors leading to such changes are unknown in Sarus Cranes. In this note, I report the first evidence of divorce or separation in Sarus Cranes with observations on other aspects of pair bond and territoriality.

Over two hundred and fifty breeding, territorial pairs of Sarus Cranes were monitored between December 1999-July 2002 as part of a study on their biology and conservation in the districts of Etawah and Mainpuri in Uttar Pradesh. The study area has the highest known density of territorial pairs and number of Sarus Cranes anywhere in the world. Pairs/families were recognized by colour-banding the juveniles each year, with individual physical marks on adult birds, or by location. Pairs, particularly those with young, were observed one to seven times a week (average of four observations) to collect data on breeding success, feeding habits, territory size, and activity budgets. Mate change was observed in two instances and is discussed in this note. "Divorce" or change of pair membership was actually observed in one pair, while mate change could be deduced in another. In addition, other relevant aspects of pair bonding, territoriality, and related behaviours observed are described and discussed. The behaviour terminology used throughout the text follows Ellis *et al.* (1998).

Mate change observation 1

The territory of one pair was very close to the town of Etawah, and consisted of a large *Typha*-bordered marshland and crop fields. The pair had successfully raised one chick during the breeding season in 1999-2000, and was seen to defend the territory from other Sarus pairs and groups throughout the observation period. In early August, the adult birds were observed to chase the sub-adult from the territory, and the frequency of duet calls (which is also used for advertisement during territorial defence, Archibald 1976) increased. In mid-August, the pair constructed a nest of *Typha* reeds in the marshland and the female laid two eggs, both of which were removed by villagers.

On September 8, 2000, during a routine visit to the area, another bird was seen in the territory and repeated attempts by the resident pair to chase the visitor (duet calls, tertial-elevation struts and co-ordinated guard calls) failed to elicit a response. In a surprising move, the visitor attacked the resident female (identified by smaller size and posture during duet calls). At first, the male assumed threat postures and carried out displacement preens, tertial-elevation struts, and a directed walk threat at the visitor. These attempts failed to displace the visitor, which instead renewed attacks on the resident female. The visitor was smaller than the resident male, but larger than the resident female. The resident female and the visitor sparred for almost five minutes, pecking each other and indulging in rapid, violent bouts of jump-rakes. The resident female was clearly losing the battle; the larger size of the visitor could have proved to be an advantage. At this point, the resident male, which was otherwise circling the fighting pair of cranes, walked in and pecked the resident female. The resident female began running away from the visitor, giving alarm-calls, and the male responded by calling synchronously, but did not come to the rescue. The visitor became very aggressive and mounted a fresh attack on the resident female by kicking, jump-raking, wing-thrashing, sitting on the back of the bird and pecking the neck and head hard and rapidly, finally chasing the bird into a pond and forcing it to swim to the opposite bank. The male was now chasing the resident female as well, and clearly supporting the visitor, though he synchronously answered the alarm and guard-calls of the resident female.

On emerging from the lake, the resident female was pursued once again by the visitor. This time, the female deliberately, but cautiously, approached human observers standing on the side of the marshland and stood as close as 5 m. This dissuaded the visitor from attacking further and she